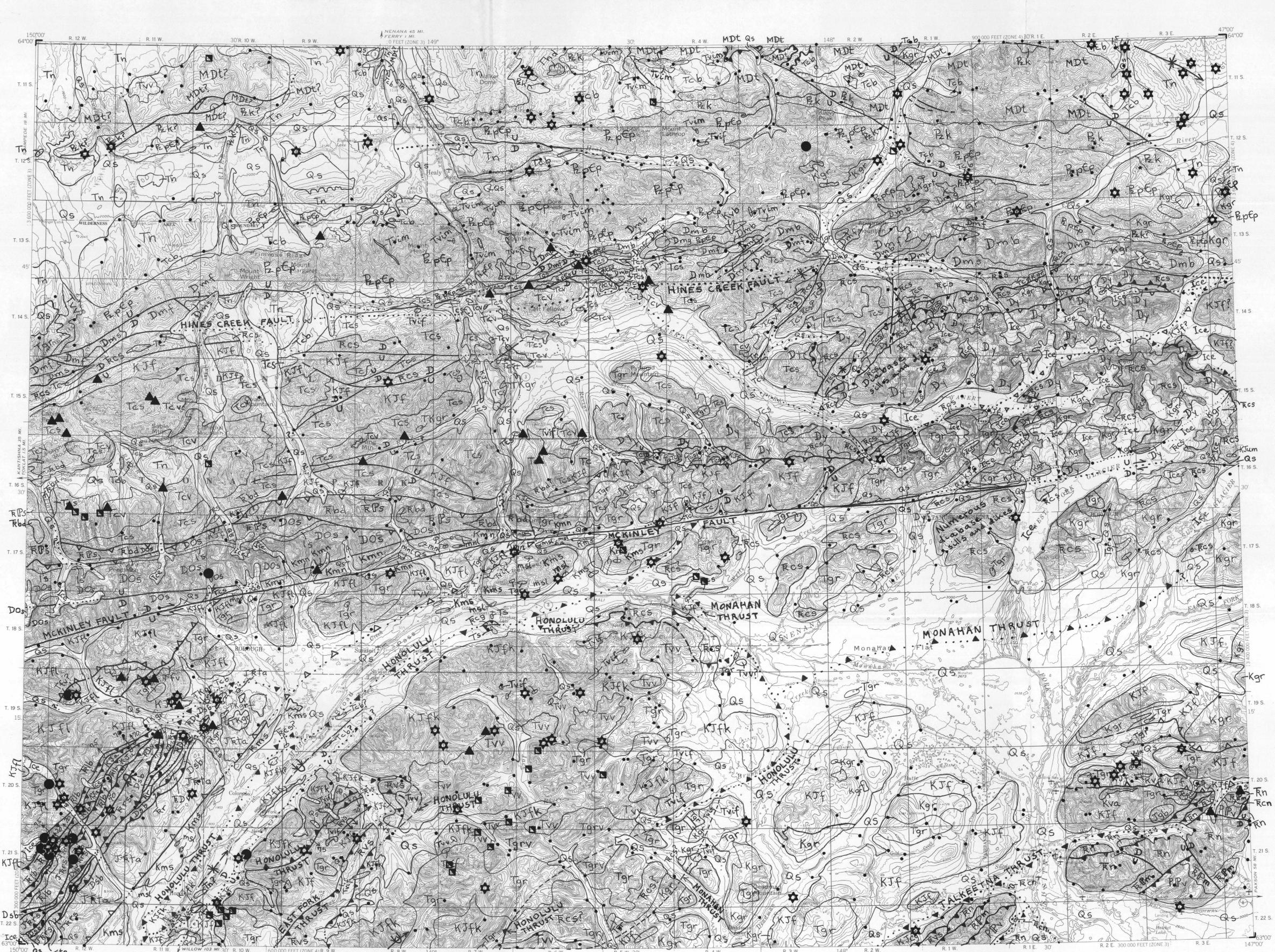
Geology modified from Csejtey and others, 1986

MAP A. DISTRIBUTION OF ARSENOPYRITE, CHALCOPYRITE, GALENA, AND SPHALERITE



EXPLANATION FOR MAP A

- Arsenopyrite
- Chalcopyrite

- Sample site None of the above minerals identified; amounts for the above minerals may exceed 30 percent by volume of the nonmagnetic fraction

DESCRIPTION OF MAP UNITS ALL AREAS OF THE QUADRANGLE

- Os Surficial deposits (Quaternary)
- Thd Hornblende dacite (Pliocene) Nenana Gravel (Pliocene and Miocene) — Poorly consolidated conglomerate and sandstone
- Tcb Coal-bearing rocks (Miocene to Eocene) Sedimentary rocks (Miocene? to Paleocene?) — Mainly poorly consolidated shale, sandstone,
- siltstone, and conglomerate Volcanic rocks (Oligocene to Paleocene) Flows, pyroclastic rocks, and subvolcanic intrusions — Subaerial volcanic rocks and
- subordinate dikes ranging in composition from basalt to rhyolite Mafic subvolcanic intrusive rock s — Mainly dikes of basalt and subordinate andesite
- Felsic subvolcanic intrusive rocks Mainly dikes of rhyolite and dacite Tgr Granitic rocks (Oligocene to Paleocene) — Mainly granite and granodiorite Tgrv Granitic and volcanic rocks, undivided (Oligocene to Paleocene) — Border zone between
- granitic rocks and Tertiary volcanic rocks Fluviatile and volcanic rocks (Eocene?) — Mainly conglomerate, sandstone, and siltstone and a few thin flows of basaltic andesite
- Cantwell Formation (Paleocene) Volcanic rocks subunit — Flows of andesite, basalt, rhyolite, and dacite and pyroclastic felsic
- Sedimentary rocks subunit Mainly conglomerate, sandstone, and shale and a few thin coal beds, volcanic flows, and tuff units

TKgr Granitic and hypabyssal intrusive rocks (Paleocene? and Late Cretaceous) — Mainly

NORTHERN, EASTERN, AND SOUTH-CENTRAL

- AREAS OF QUADRANGLE Kva Andesitic subvolcanic intrusive rocks (Late Cretaceous) — Hornblende andesite
- Granitic rocks (Late and (or) Early Cretaceous) Mainly tonalite, quartz diorite, and granodiorite; generally well foliated Kgrt Tourmaline-bearing granite (Late or Early Cretaceous)
- KJf Flysch sequence (Early Cretaceous and Late Jurassic) Graywacke turbidite, shale, siltstone, and conglomerate; metamorphosed in southeast part of area KJfk Overthrust flysh-like rocks (Early Cretaceous and Late Jurassic) — Lithology identical to unit
- KJcg Conglomerate, sandstone, siltstone, shale, and volcanic rocks (Early Cretaceous and Late
- KJum Ultramafic rocks (Early Cretaceous or Jurassic) Plagioclase-bearing peridotite
- Alkali gabbro (Late Jurassic)
- Dmg Metagabbro (Late Devonian?)

Yukon-Tanana terrane

- Basaltic subvolcanic rocks (Late Cretaceous) Mainly dike swarms RCS Calcareous sedimentary rocks (Late Triassic; middle? Norian to late Karnian) — Locally metamorphosed, carbonaceous, calcareous shale and sandstone, and sandy to silty limestone. Includes sills and dikes of gabbro
- Totatlanika Schist (Early Mississippian to Middle Devonian) Carbonaceous slate, phyllite, and schist; metachert, quartz-orthoclase-sericite schist, and augen gneiss; metavolcanic rocks
- Yanert Fork sequence (Late Devonian) Carbonaceous siliceous mudstone, slate, phyllite, and schist; impure quartzite and metachert, metavolcanic rocks, and marble interbeds. Also dikes
- Dmf Felsic metavolcanic rocks (Late Devonian) Metamorphosed rhyolite and quartz latite Dmb Metabasalt and subordinate metasedimentary rocks (Late Devonian) — Greenschist, metabasalt, and carbonaceous phyllite
- Metasedimentary rocks (Late Devonian) Sericite schist, black slate, and chert Keevy Peak Formation (early Paleozoic) — Mainly sericite schist, quartzite, arkosic schist, and
- Pap€p Pelitic and quartzose schist sequence (early Paleozoic and Precambrian?) Quartz sericite
- (carbonate) schist, quartzite, and black phyllite Talkeetna superterrane (includes Wrangellia terrane)

Metavolcanic, metavolcaniclastic, and subordinate metasedimentary rocks (Late Triassic; late Norian) — Marine basalt, tuff, slate, and diabase sills

- Chitistone and Nizina Limestones, undivided (Late Triassic; early Norian and late Karnian) Nikolai Greenstone (Late and (or) Middle Triassic) — Mainly subaerial flows of amygdaloidal
- RPm Metasedimentary rocks sequence (Middle Triassic to Late Pennsylvanian?) Black argillite, thin beds of volcanic breccia and sandstone, and limestone overlain by thin-bedded chert.
- Andesitic volcanic rocks (Early Permian? and Pennsylvanian) Volcanic flows and breccias;
- probably marine

SOUTHWESTERN AND WEST-CENTRAL AREAS OF QUADRANGLE

Kms Melange south of McKinley fault (Late and (or) Early Cretaceous) — Dark-gray flysch, cherty tuff, volcanic sandstone, and blocks of limestone (msl) Kmn Melange north of McKinley fault (Late and (or) Early Cretaceous) — Similar to unit Kms, but

contains recrystallized limestones (mnl) and ophiolitic rocks (mno), mainly serpentinite,

- KJfl Flysch sequence (Late Cretaceous to Late Jurassic)
- KJf Flysch sequence (Early Cretaceous and Late Jurassic) KJa Argillite, chert, limestone, and sandstone (Early Cretaceous and Late Jurassic)
- JEta Crystal tuff, argillite, chert, graywacke, and limestone (Late Jurassic to Late Triassic?) JErs Red and brown sedimentary rocks and basalt (Early Jurassic and Late Triassic) — Red
- sandstone, siltstone, conglomerate, and basalt overlain by brown sandstone and siltstone Rcg Conglomerate and volcanic sandstone (Late Triassic)
- Rbd Basalt, diabase, and subordinate sedimentary rocks (Late Triassic; Karnian and Noria Rlb Limestone and basalt sequence (Late Triassic)

basalt, and chert

- Red beds (Late Triassic) Red sandstone, siltstone, and conglomerate Flysch-like sedimentary rocks (Late Triassic to Pennsylvanian) — Impure sandstone, siltstone, and shale; minor limestone and chert
- RDv Volcanogenic and sedimentary rocks (Early Triassic to Late Devonian) Tuffaceous chert, mudstone, and basalt breccia; flysh-like graywacke and mudstone; limestone
- Serpentinite, basalt, chert, and gabbro (Late Devonian) Nixon Fork terrane

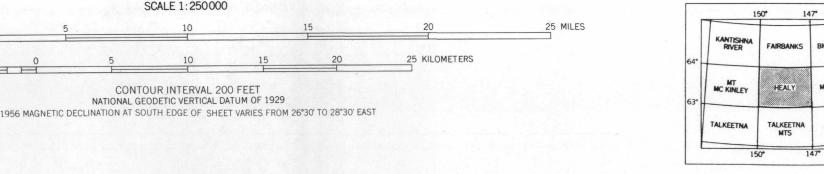
Sedimentary rocks sequence (Middle Devonian to Ordovician) — Black argillite and siltstone, massive limestone (ls), thin-bedded limestone, and chert

Contact — Approximately located Thrust fault — Showing direction of dip of overturned thrust

- fault. Dashed where inferred; dotted where concealed. Sawteeth on upper plate
- High-angle reverse fault Dashed where inferred; dotted Fault — Dashed where inferred; dotted where concealed. Where
- isplacement is known, U, upthrown side, D, downthrown side; arrows indicate relative horizontal movement
- ---- Postulated position of fault prior to intrusion of plutonic and subvolcanic rocks
- Anticline Showing direction of plunge Overturned anticline — Showing direction of dip of limbs and

plunge. Dashed where inferred

- Syncline Showing direction of plunge. Dashed where inferred Overturned syncline — Showing direction of dip of limbs and



EXPLANATION FOR MAP B

Base from U.S. Geological Survey, 1956

Sample site — None of the above minerals identified; amounts of the above minerals are less than 20 percent by volume of the nonmagnetic fraction

Base-metal sulfides, gold, cassiterite, and scheelite found in concentrate samples collected in the Upper Chulitna mining district are related to known deposits in several areas. In the area of upper Partin Creek, sulfide minerals are present along a stretch that runs at least 2 mi downstream from the known sulfide deposit; in the area of Bryn Mawr Creek, downstream from the Golden Zone mine, ore-related minerals found in concentrate samples persist to the mouth of the creek. High concentrations of several ore-related minerals found in concentrate samples collected in and near Canyon Creek indicate the presence of significant mineralization. Cassiterite and scheelite found in concentrate samples collected from Coal Creek (T. 22 S., R. 12 W.) may indicate the presence of mineralized rocks nearby, despite the fact that these minerals are not related to known deposits. A corresponding stream-sediment sample contains anomalous concentrations of

Cr, Ni, Sn, and Zn (King and others, 1989).

INTRODUCTION

Healy quadrangle was conducted during 1980-1982 as part of the Alaskan Mineral

result of the various AMRAP investigations, a mineral resource evaluation of the

Resource Assessment Program (AMRAP) of the U.S. Geological Survey (USGS). As a

quadrangle was published by Cox and others (1989). The Healy quadrangle comprises

Anchorage. The quadrangle is traversed by the central Alaska Range, which forms a

glacially sculptured arcuate mountain wall with a maximum elevation of 12,339 ft (Mt.

sample sites was provided by helicopters, with the exception of a few sites that were

accessible by automobile from the Denali and George Parks highways.

Deborah). The lowest elevation is about 1,000 ft along the Nenana River. Access to the

As part of the AMRAP program, a summary of the geology of the Healy quadrangle

was published by Csejtey and others (1992), from which much of the geology overview for

this report is taken. The Healy quadrangle lies along the accretionary continental margin of

North America. There are extensive exposures of pre-accretion rocks of the ancient North

Paleozoic schists, phyllites, and metavolcanic rocks of the Yukon-Tenana terrane. The

sedimentary rocks and Tertiary clastic sedimentary and coal-bearing units (Wahrhaftig,

1968, 1970) are also present in this part of the quadrangle. The rocks in the southern half of

the quadrangle are composed of a highly deformed and metamorphosed Late Jurassic and

deposition in an oceanic basin between the converging Yukon-Tenana and Wrangellia

MacKevett and Holloway (1977), and Cobb (1978) reported the presence of placer-gold

deposits east of Suntrana (T. 12 S., R. 6 W.) and extending eastward from Jumbo Dome (T.

deposits in the northeastern corner of the quadrangle, lode-gold and base-metal deposits

located between Wood River and West Fork Little Delta River, and base- and precious-

metal deposits in the area of the Reindeer Hills (T. 17 S., R. 6, 7 W.). Hawley and Clark

W.). The Valdez Creek mining district consists of several lode-gold, lode-copper, and

base-metal deposit within the Valdez Creek district is described in Stevens (1972) and

quadrangle, contains epigenetic gold and base-metal deposits, and at least one unit of tin-

METHODS USED IN MINERALOGICAL STUDY

Three sample types were collected in the Healy quadrangle: stream sediments from

1,064 sites, heavy-mineral concentrates from 1,045 of the stream-sediment sites, and

be collected because of glacial-ice cover in the drainage basins (35 sites). Most of the

samples were collected from active first-order (unbranched) streams and second-order

topographic maps (scale 1:63,360). The streams drain areas that range from about 1.5 mi²

PREPARATION OF THE SAMPLES

sieving alluvial material through a 2-mm-mesh stainless steel screen into a 14-in. steel gold

pan. Composite glacial-debris samples were collected by screening morainal material into

The resultant minus-80-mesh fraction from each sample was analyzed for 31 elements

using a semiquantitative, direct-current arc emission spectrographic method (Grimes and

Maranzino, 1968). The spectrographic results obtained from the analysis of the stream-

glacial-debris samples to remove most of the quartz, feldspar, schist, organic material, and

clay-size particles. The panned-concentrate samples were air dried and sieved through a

bromoform (specific gravity 2.85) to remove the remaining light minerals. Magnetic iron

oxides and high-iron silicates were removed from each heavy-mineral-concentrate sample

The nonmagnetic heavy-mineral fraction was visually inspected using a binocular

microscope and short-wave ultraviolet light to identify ore and ore-related minerals. Most

analysis was used to confirm some mineral species. The visual examination is an important

supplement to spectrographic analysis because the particulate nature of malleable minerals

such as gold, silver, copper, and platinum-group minerals may be poorly represented in the

spectrographic sample. In addition, visual examination identifies artifacts (bullet and solder

MINERALOGICAL RESULTS OF EXAMINATION OF

HEAVY-MINERAL FRACTION OF STREAM-SEDIMENT SAMPLES

microscope to identify ore-related minerals. The most common ore-related minerals in the

samples, their chemical formulas, and the number of samples containing each mineral are

as follows: arsenopyrite, FeAsS (315); chalcopyrite, CuFeS₂ (364); galena, PbS (283);

gold, Au (100); sphalerite, ZnS (220); cinnabar, HgS (34); fluorite, CaF₂ (26); stibnite,

Sb₂S₃ (9); cassiterite, SnO₂ (135); powellite, Ca(Mo, W)O₄ (26); and scheelite, CaWO₄

map A; the distribution of antimony-, fluorine-, gold-, and mercury-bearing minerals is

is shown on map C. The maps include topographic and geologic base maps.

(496). The distribution of arsenic-, copper-, lead-, and zinc-bearing minerals is shown on

shown on map B; and the distribution of molybdenum-, tin-, and tungsten-bearing minerals

DISTRIBUTION OF CONCENTRATE MINERALS

concentrate samples containing arsenopyrite, chalcopyrite, galena, and sphalerite are

and metavolcanic rocks of the Totatlanika Schist and Late Devonian greenschist, and

the east-central part of the quadrangle, the localities of samples containing base-metal

sequence, and the sedimentary rocks of the Late Jurassic and Early Cretaceous flysch

distributed in several bands across the Healy quadrangle. An area north of the Hines Creek

fault delineated by the northernmost mineral-distribution band contains metasedimentary

Precambrian to early Paleozoic pelitic and quartzose schist. South of Hines Creek fault in

sulfides are distributed in the metasedimentary and metavolcanic rocks of the Yanert Fork

sequence. Concentrate samples containing base-metal sulfide minerals were collected from

an area in the southwest corner of the quadrangle that contains mostly Mesozoic volcanic

and sedimentaryrocks; this area includes the Upper Chulitna mining district. Localities of

samples containing sulfide minerals are distributed over a large area in the southwestern

Cretaceous flysch sequence, and Paleocene to Oligocene volcanic rocks. The distribution

of base-metal sulfide minerals in concentrate samples is suggestive of the shape and extent

SOUTHWESTERN AREA OF QUADRANGLE

The southwestern part of the quadrangle contains epigenetic mineral deposits in

deposits contain arsenopyrite, chalcopyrite, pyrrhotite, cassiterite, stibnite, and gold. Gold,

Some of the concentrate samples collected from the Upper Chulitna mining district

serpentine in the Upper Chulitna mining district (Hawley and Clark, 1974). Several

copper, and arsenic are present in localized anomalous concentrations delineated by

and containing ore-related minerals were collected from sites located upstream from

intersections with mineralized areas or streams draining weakly mineralized areas. For

in Colorado Creek (T. 19 S., R. 11 W.). These concentrate samples contain arsenopyrite,

minerals, including chalcopyrite. The Silver King deposit, a vein and breccia-pipe type

example, three concentrate samples were collected upstream from the Silver King deposit

galena, sphalerite, gold, cinnabar, cassiterite, and scheelite. A concentrate sample collected

downstream from the Silver King deposit lacks cinnabar, but otherwise contains the same

deposit, contains chalcopyrite as disseminations in quartz diorite porphyry and in tactite in

argillite and greenstone hornfels (Hawley and Clark, 1968). The absence of chalcopyrite

King deposit may indicate the presence of a low-temperature mineral deposit in the upper

The rocks within the Blind Creek fault zone (Tps. 19 and 20 S., R. 11 W.) are

zone contains localized quartz veins and quartz-cemented breccia zones as much as 200 ft

described as only weakly mineralized (Hawley and Clark, 1968). The rocks of the fault

across. The massive to opalescent coloform quartz contains limonite and pyrite. A chip

sample collected from the most pyritic part of the vein assayed at 0.30 ppm Au (Hawley

and Clark, 1968). Values of 150 ppm Pb and less than 200 ppm Zn (limit of detection)

were also reported. A concentrate sample collected downstream from the fault zone

contains arsenopyrite, chalcopyrite, cassiterite, sphalerite, galena, and scheelite. This

mineral assemblage indicates that the fault zone may be more mineralized locally than

reported earlier, or that other more mineralized veins exist in the area. A stream-sediment

sample collected downstream from the fault zone is enriched in molybdenum, gold, and

upstream from the Copper King prospect. As a group, these samples contain galena,

arsenopyrite, chalcopyrite, sphalerite, and scheelite. The Copper King prospect has vein

disseminations in volcanic siltstone and conglomerate, all of which are cut by quartz

and massive replacement deposits of copper sulfide minerals within favorable strata, and

porphyry dikes and plugs (Hawley and Clark, 1968). Minerals present in the concentrate

samples collected upstream from the Copper King prospect may indicate that there are

similar copper-rich deposits in the upper watershed of Long Creek.

chalcopyrite, galena, stibnite, sphalerite, cassiterite, and scheelite.

Five concentrate samples were collected in the Long Creek area (T. 20 S., R. 11 W.)

Pyrite, arsenopyrite, pyrrhotite, and chalcopyrite were found in a zone that is 3,000 ft

long and as much as 1,000 ft wide in the Partin Creek area (T. 21 S., R. 13 W.; Hawley and

Clark, 1969). Samples contained as much as 300 ppm Ag, 63 ppm Au, 100 ppm Pb, 7,000

ppm Sb, and 300 ppm Zn. Three stream concentrate samples collected from tributaries of

and galena, indicating that other sulfide-mineral deposits may be found in the amygdaloidal

The Canyon Creek deposit (T. 20 S., R. 12 W.) contains sulfides in interlayered

basalt and limestone (Hawley and Clark, 1968). Veins of quartz, arsenopyrite, and other

sulfides contain as much as 500 ppm Ag, 0.9 ppm Au, 500 ppm Cd, 5,000 ppm Cu, more

than 20,000 ppm Pb, more than 1,000 ppm Sn, 3,000 ppm Sb, and 10,000 ppm Zn. The

Gold, arsenopyrite, chalcopyrite, galena, sphalerite, and scheelite are present in

Many concentrate samples collected from the Upper Chulitna mining district (map

concentrate sample collected from Canyon Creek contains visible gold, arsenopyrite,

concentrate samples collected from Shotgun and McCallie Creeks (T. 21 S., R. 12 W.),

both of which head in limestone and basalt. The mineralogical data indicate that other

mineral deposits may be present in rocks similar to those of Partin and Canyon Creeks.

(Hawley and others, 1969). Several samples of the greisen and pegmatitic quartz-

arsenopyrite veins in contact with country rock contain more than 1,000 ppm Sn. A

granitic bodies with associated greisen and tin-bearing veins are present in the area.

concentrate sample collected from a tributary of Ohio Creek located about 1.3 miles

C) contain cassiterite. The source rocks of the cassiterite are granitic stocks known to be

present in the district. A granitic stock that crops out in upper Ohio Creek (T. 20 S., R. 12

W.) consists of muscovite- and tourmaline-bearing greisen cut by quartz-arsenopyrite veins

southwest of the stock contains cassiterite, arsenopyrite, and scheelite, as well a 3,000 ppm

B and 200 ppm Bi. The presence of this suite of minerals and elements indicates that other

Partin Creek downstream from the mineralized zone contain arsenopyrite, chalcopyrite,

basalt, a depositional environment similar to that of the Partin Creek deposit.

and the presence of cinnabar in concentrate samples collected upstream from the Silver

stream-sediment samples collected in this area (King and others, 1989).

watershed of Colorado Creek.

copper (King and others, 1989).

and south-central parts of the quadrangle that contain mostly rocks of the Jurassic and

of areas that might contain metallic mineral resources; these areas are discussed below.

One of the more striking mineral-distribution patterns is seen on map A: localities of

For this study, 1,045 concentrate samples were visually inspected using a binocular

fragments, wire, or other man-made contaminants) that give inflated metallic values.

of the mineral grains were identified by their physical properties, but X-ray diffraction

30-mesh sieve. The resultant minus-30-mesh fraction was further separated using

using a magnetic separator. The removal of magnetic minerals from the concentrate

samples enhances the spectrographic detection of ore-related elements and makes

The stream-sediment and heavy-mineral-concentrate samples were obtained by wet

In the laboratory, the stream-sediment samples were sieved using an 80-mesh sieve.

(downstream from junction of two first-order streams) streams, as determined from

to 5 mi². The sampling method was designed to relate mineralogical and geochemical

anomalies to specific drainage basins as part of the mineral resource assessment.

the gold pan and then processing each sample as a stream-sediment sample.

sediment samples are available in O'Leary and others (1984).

identification of mineral grains easier.

composite glacial debris from tributary glaciers where stream sediment samples could not

placer-gold deposits in the Clearwater Mountains in the southeastern corner of the

Seraphim (1975). The Upper Chulitna district, in the southwestern corner of the

bearing greisen (Hawley and Clark, 1974).

(1968) located a gold-antimony deposit about 6 mi northeast of Honolulu (T. 21 S., R. 10

quadrangle (Ross, 1933; Tuck, 1938; Kaufman, 1964; Smith, 1981). The Denali stratiform

11 S., R. 6 W.) to Moose Creek along the northern boundary of the quadrangle, placer-gold

terranes (Csejtey and others, 1986). The Wrangellia terrane is located south of the

Talkeetna thrust in the southeastern corner of the Healy quadrangle.

Early Cretaceous flysch sequence and several thrust sheets. The flysch sequence represents

There are many known mineral deposits in the quadrangle. Clark and Cobb (1972),

metavolcanic rocks of the Yukon-Tenana terrane are intruded by locally abundant

Cretaceous quartz diorite and Tertiary granite and granodiorite. Triassic calcareous

American continent in the northern half of the quadrangle; these rocks include Cambrian to

6,700 mi² in southern Alaska and is located 60 mi south of Fairbanks and 120 mi north of

A reconnaissance mineralogical and geochemical survey of stream sediments in the

Arsenopyrite, chalcopyrite, galena, and sphalerite found in concentrate samples and that the mineral resource potential of these areas is good. thrust fault, host Late Jurassic and Early Cretaceous flysch, and Tertiary granitic and

The distribution patterns of arsenopyrite, chalcopyrite, galena, and sphalerite found in the concentrate samples (map A) indicate that these minerals are widespread and abundant in most of the area. Scheelite (map C) is also particularly widespread over most of the area. Gold was found at 15 sample sites and cassiterite was found to be widely distributed. These minerals are particularly abundant in samples collected from streams Hurricane Gulch (T. 22 S., R. 10 W.) to Crooked Creek (T. 20 S., R. 8 W.). The presence of gold, arsenopyrite, chalcopyrite, galena, and sphalerite in concentrate samples that precious- and base-metal deposits are present in the flysch and metavolcanic rocks. The

The presence of a suite of heavy minerals in concentrate samples collected from tin and precious- and base-metal deposits, but because there is little known about

Concentrate samples containing gold, base-metal sulfides, powellite, and scheelite were collected from streams draining the belt of metasedimentary and metavolcanic rocks of the Yukon-Tanana terrane north of the Hines Creek fault. About 60 lode and placer deposits are known to be present in this area (Bottge and Northam, 1985). Disseminated sulfides were found in outcrops in the vicinity of Dora Peak (Tps. 12 and 13 S., Rs. 5 and 6 W.), on the north flank of Anderson Mountain (T. 13 S., R. 2 W.), in a tributary of Kansas Creek (T. 12 S., R. 1 W.), and near the head of Healy Creek (T. 13 S., R. 4 W.). There are known mineralized areas, including one gold prospect and several gold- and base-metalsulfide-bearing deposits, on Kansas and Glory Creeks (Clark and Cobb, 1972). The Glory Creek occurrence (T. 12 S., R. 1 E.) contains several quartz-gold-sulfide-scheelite veins.

- Gold-bearing pyrite is disseminated in altered rhyolite porphyry in schist on Chute Creek (T. 12 S., R. 1 W.; Cobb, 1978). One concentrate sample contained arsenopyrite, sphalerite, and galena (map A). A small prospect on Rock Creek (T. 12 S., R. 1 W.; Berg and Cobb, 1967) contains stibnite in stretched-pebble conglomerate. A concentrate sample collected from this creek contained galena, although no stibnite was found. Little information is available about a lead-silver prospect located near the Sushana
- here contained galena, sphalerite, and scheelite. The distribution of samples containing base-metal sulfides indicates that massive
- of the quadrangle. This trend is consistent with that of the Yukon-Tanana terrane in the adjacent Mt. Hayes quadrangle (Tripp and others, 1993; Nokleberg and others, 1990). In the Mt. Hayes quadrangle, the Yukon-Tanana terrane contains substantial localized Kuroko-type podiform sulfide deposits that contain chalcopyrite, galena, sphalerite, pyrite, and pyrrhotite in association with As, Ag, Au, Sb, and Sn (Nokleberg and others, 1990). The distribution of concentrate samples collected in the Healy quadrangle that contain sulfides indicates that similar massive-sulfide deposits are irregularly shaped, discontinuous, fault-bounded pods, lenses, and stringers in the Yukon-Tanana terrane. Map B shows that both placer- and lode-type gold deposits are widely distributed
- by reworking of the Tertiary Nenana Gravel; only very few placer-gold deposits may be derived from schist of the Yukon-Tanana terrane. In the Mt. Hayes quadrangle, the lodegold deposits found in the Yukon-Tanana terrane are mostly contained in small quartz veins or epithermal precious-metal deposits that formed in metasedimentary schist during regional metamorphism and (or) intrusion of granitic plutons (Nokleberg and others, 1990). The association of scheelite with gold in concentrate samples collected in the Mt. Hayes quadrangle indicates that the lode-gold deposits are tungsten rich (Tripp and others, 1993). The weathering of these lode deposits in the Yukon-Tanana terrane produced small (but sometimes rich) placer-gold deposits. Lode-gold deposits found in the Yukon-Tanana terrane in the Healy quadrangle appear to have similar characteristics, that is, small tungsten-rich quartz veins that are widely and sparsely distributed within the terrane. The Nenana Gravel overlies much of the Yukon-Tanana terrane in the northeast
- corner, north-central area, and northwest corner of the Healy quadrangle. The Nenana Gravel hosts several placer-gold deposits (T. 11 S., R. 2 E.; T. 11 S., Rs. 4-7 W.; T. 12 S., R. 3 E.; and T. 12 S., Rs. 6 and 7 W.) (Cobb, 1978; Bottge and Northam, 1985). Our while some other deposits contain cassiterite. The data also indicate that placer-gold Nenana Gravel in the northwestern area of the quadrangle.
- S., R. 6 W.) indicates that precious- and base-metal deposits may be present in fault wedges of rocks of the Cantwell Formation.

The areal distribution of arsenopyrite, chalcopyrite, galena, and sphalerite in

WESTERN, CENTRAL, AND EASTERN AREAS

concentrate samples collected south of the Hines Creek fault indicates that the Triassic metasedimentary rocks, the Yanert Fork sequence, and the Jurassic and Cretaceous flysch may host disseminated- and massive-sulfide deposits. Most concentrate samples collected in the east-central part of the quadrangle contain sulfides in quantities indicating relatively extensive sulfide mineralization. Sherwood and others (1976) found sulfide deposits in the upper part of the Wood River area of Edgar Creek (T. 15 S., R. 2 W.) and near the head end of West Fork glacier (T. 15 S., R. 2 E.). Much of the sulfide mineralization in these three areas is present in contact zones adjacent to gabbro sills and the granitic rocks that cut the Triassic metasedimentary rocks. Weathering and oxidation of the sulfide-bearing contact rocks produced many conspicuous gossan zones, many of which are copper rich. Some sulfide-rich outcrops associated with gabbro contain abundant pyrrhotite and smaller amounts of chalcopyrite. Malachite was found in the subsidiary fractures of the Hines Creek fault and foliations of the adjacent sedimentary rocks. Boulders of sulfide-rich gossan were found in debris on slopes adjacent to West Fork glacier. MacKevett and Holloway (1977) found chalcopyrite and sphalerite in a submarine volcanogenic-type deposit in Paleocene metamorphic rocks near West Fork glacier (T. 17 S., R. 1 E.). Rocks of the Cantwell Formation that crop out in the central part of the quadrangle

chalcopyrite. However, the interpretation of the mineral-distribution patterns indicated by both stream-sediment and glacial-debris concentrate samples collected in the central and eastern parts of the quadrangle has to be tempered by consideration of what influences glaciation may have had on dispersing minerals from their source rocks. Analyses of the concentrate samples indicate that gold is rare in the central part of the quadrangle. Two placer-gold deposits are located in the area, one on Yanert Fork (T. 14 S., R. 6 W.) and the other on Grizzly Creek (T. 13 S., R. 3 W.) (Bottge and Northam, 1985). The gold contents of two concentrate samples indicate the presence of lode-gold deposits in an area of Nenana Mountain (T. 16 S., R. 2 W.), where Tertiary granite intrudes Jurassic and Cretaceous flysch. The granite is tin and tungsten enriched because cassiterite

central and eastern parts of the quadrangle. and Tertiary granitic rocks widely distributed across the quadrangle and bounded by the Hines Creek and McKinley faults. The presence of cassiterite and fluorite in concentrate samples collected from the area at T. 17 S., R. 12 W. indicates that lode-tin deposits may massive-sulfide deposits also may be present because galena, arsenopyrite, chalcopyrite cinnabar, and sphalerite are also present in concentrate samples. Concentrate samples

indicate that Cantwell Formation rocks may host lode-tin deposits at Calico Creek (T. 16 S., R. 10 W.) and Carlo (T. 16 S., R. 7 W.), and base-metal sulfide deposits north of Polychrome Mountain (T 15 S., R. 12 W.) and Sable Mountain (T. 15 S., R. 11 W.). Concentrate samples collected from streams draining the Nixon Fork terrane in the western part of the quadrangle contain arsenopyrite, chalcopyrite, galena, and sphalerite. The relativly small amount of mineralogical data for rocks in the area precludes making statements concerning the potential for the occurrence of specific mineral deposits.

Concentrate samples collected from Cretaceous tectonic-melange rocks south of the McKinley fault contain gold, cassiterite, scheelite, and arsenopyrite. A possible source of the gold is quartz veins in the Reindeer Hills (T. 17 S., R. 6 W.) associated with Tertiary granite that cuts the melange rocks. The scheelite may be derived from metamorphosed quartz veins within the melange rocks and from skarn rocks. The presence of arsenopyrite, cassiterite, and fluorite in concentrate samples collected from Pyramid Peak (T. 17 S., R. 4 W.) and the peak to the west may indicate the presence of tin-greisen deposits in Tertiary granite. Clark and Cobb (1972) located three lode-mineral deposits in the Reindeer Hills area that collectively contain gold, copper, molybdenum, and nickel.

malachite, and erythrite were found in a skarn deposit in a quartz diorite, limestone, and argillite contact zone. Within 1.5 mi of the skarn deposit, pyritized and silicified argillite and graywacke are cut by veins of sphalerite and stibnite. Between Little Windy Creek and Basin Creek, gossan associated with a porphyritic rhyolite dike is present in argillite and graywacke. Concentrate samples collected from the Windy Creek watershed contain arsenopyrite and galena. The mineral content of the concentrate samples and the frequency and distribution of lode-mineral deposits indicate that mineralization occurred in the rocks of the area, and that they may contain skarn and base-metal-sulfide vein deposits. Bottge and Northam (1985) described two claims northwest of West Fork glacier (T. 16 S., R. 1 E.). Concentrate samples contained gold, galena, arsenopyrite, and scheelite that may have been derived from local gabbro dikes and sills in the Triassic sedimentary rocks. The geology of the area and minerals found in concentrate samples indicate that the area's rocks may contain precious- and base-metal sulfide deposits.

an area that contains numerous precious- and base-metal sulfide deposits. Bottge and Northam (1985) identified about 20 lode and placer deposits. Cobb (1978) discussed about 19 lode- and placer-mineral deposits; Clark and Cobb (1972) identified 20 lode deposits and five placer deposits in the Valdez Creek district. Most of the gold from the Valdez Creek district came from the placer deposits; the most productive placer deposit is the

collected from tributaries of Costello Creek (T. 18 S., R. 11 W.) and the upper reaches of Copeland Creek (T. 20 S., R. 12 W.) characterize two areas that may contain base-metal deposits. The distribution of the sulfide minerals in concentrate samples collected in these two areas indicates that sulfide-bearing rocks crop out over a distance of thousands of feet Concentrate samples collected from streams draining an area of approximately 540 mi² located east of the Upper Chulitna mining district contain base-metal sulfides, fluorite, scheelite, cassiterite, and gold. The rocks of this area, which is bounded by the Honolulu volcanic rocks. Few lode- and placer-mineral deposits are known to be present in the area (Bottge and Northam, 1985). Several lode-mineral deposits are located east of Honolulu (T. 22 S., R. 10 W.) and in the upper reaches of a tributary of Tsusena Creek (T. 22 S., R. 6 W.). Gold and antimony are present in quartz veins near the head of Antimony Creek (T. 21 S., R. 10 W.; Capps, 1919; Hawley and others, 1969). Placer deposits were found on a tributary of Jack River (T. 18 S., R. 6 W.) and the lower reaches of Edmonds Creek (T. 18 S., R. 5 W.) and Seattle Creek (Tps. 18 and 19 S., R. 4 W.).

that drain a northeast-trending belt of flysch, metavolcanic, granitic rocks that extends from presence of cassiterite, scheelite, and fluorite may indicate that there is potential for tin and ungsten deposits in and near the granitic rocks.

streams draining the volcanic rocks in the area of Caribou Pass (T. 19 S., R. 7 W.) and the middle to upper reaches of Jack River may indicate the presence of volcanogenic-hosted mineralization in these volcanic rocks, any conclusions about mineral resources and types of deposits are speculative.

NORTHERN AREA OF QUADRANGLE

Mineralization in the area that extends from Copper Creek to Glory Creek is spatially related to a fault that traverses these two creeks.

- River (T. 14 S., R. 11 W.; Clark and Cobb, 1972), but a concentrate sample collected near
- and disseminated-sulfide deposits in the Yukon-Tanana terrane possess a widespread and pervasive trend that extends from Mount Margaret (T. 13 S., R. 9 W.) to the eastern border
- across the northern part of the Healy quadrangle. Most of the placer deposits were formed
- concentrate-sample data shows that many of the placer-gold deposits contain scheelite, deposits (some placer deposits may be classified as economic resources) are present in the The presence of cinnabar (in some cases, gold occurs with cinnabar) and base-metal
- sulfide minerals in concentrate samples collected in the area north of Mount Fellows (T. 14

may host base-metal sulfide deposits because concentrate samples are enriched in

and scheelite are present in the concentrate samples. The distribution of scheelite in concentrate samples coincides with the areal distribution of granitic and flysh rocks in the

Cassiterite appears to be a constituent of volcanic rocks of the Cantwell Formation be hosted by Cantwell volcanic rocks near Polychrome glacier. Several disseminated- and

Hickman and Craddock (1976) located three lode-mineral deposits northwest of Cantwell in the Windy Creek watershed (T. 17 S., R. 8 W.). Pyrrhotite, chalcopyrite,

The southeastern part of the quadrangle includes the Valdez Creek mining district,

SOUTHEASTERN AREA

quartz veins contain subordinate pyyrhotite, pyrite, chalcopyrite, galena, and sphalerite. The distribution of concentrate samples containing gold and scheelite indicates that lodeand placer-gold deposits are very likely to be present in the Valdez Creek district. Many lode deposits of copper-bearing minerals in rocks of the Wrangellia terrane are present between Butte Creek (T. 22 S., R. 1 W.) and the eastern boundary of the Healy quadrangle (Saunders, 1961). This area contains a thick section of volcanic rocks and a thin section of sedimentary rocks (Kaufman, 1964). The rocks are predominantly massive and amygdaloidal andesitic to basaltic lavas metamorphosed to greenstone in many areas. Intermediate- to basic-composition dike rocks, siliceous felsic tuff, and minor argillite and limestone are associated with these volcanic rocks. The copper deposits are found in (1) discrete quartz veins, (2) shear- or fracture-zone mineralization associated with quartz, calcite, and epidote, (3) podiform segregations, and (4) amygdule fillings. The primary minerals found in all of these types of deposits are bornite, chalcopyrite, and chalcocite, as well as minor gold and silver. Concentrate sediment samples collected from streams draining greenstone of the Wrangellia terrane contain few visible base-metal sulfide minerals. However, samples containing more sulfide minerals were collected in areas of the Wrangellia terrane where weathering produced gossan in limestone and fragmented volcanic rocks such as those

Denali bench gravel located just northeast of Denali on Valdez Creek. Gold production

until 1936 was estimated at \$1,250,000 (at \$35 per ounce; Tuck, 1938). Investigations of

the bench gravel near Denali have defined a deposit of more than 35,000,000 cubic yards

of auriferous gravel (Smith, 1970b). Recent exploration indicated estimated reserves of

79,900 ounces of gold in gravel near Valdez and White Creeks (Mining Record, 1990).

carbonate veinlets cutting intrusive and sedimentary rocks (Cobb, 1978; Smith, 1970a;

Most of the lode gold in this part of the quadrangle is contained in quartz and

Kaufman, 1962; Tuck, 1938; and Ross, 1933). Lode-gold production has been limited to a

few high-grade pockets in quartz and carbonate veins cutting quartz diorite, such as those

found at Timberline Creek and those cutting argillite and diorite at Lucky Hill (both at T.

contained almost 2 ounces of free gold (Berg and Cobb, 1967). Many of the gold-bearing

20 S., R. 2 E.). A sample of quartz about the size of a teacup collected from Lucky Hill

found at a prospect located on the South Fork of Pass Creek (T. 20 S., R. 3 E.). Here, the fragmented volcanic rock unit consists of limestone fragments in an andesitic matrix cut by several irregular gabbroic dikes (Kaufman, 1964). The gossan, which is more heavily mineralized than the fractures in the andesitic matrix, contains azurite, limonite, malachite, and minor visible chalcopyrite. Chalcopyrite found in a concentrate sample collected downstream from this area probably originated from the gossan. Twenty-seven concentrate samples collected from streams that drain the Wrangellia terrane in the mountainous area south of Windy Creek did not contain visible grains of base-metal sulfide minerals. However, this area contains six copper deposits (Kaufman,

1964). Although samples collected in this area contain no copper minerals, the copper-rich minus-80-mesh stream-sediment samples collected by King and others (1989) do confirm the presence of these lode-mineral deposits. The similar levels of copper enrichment in minus-80-mesh stream-sediment samples was discussed by Smith (1970). Concentrate samples collected from the mountainous area south of Butte Creek are devoid of visible base-metal sulfide minerals, but the minus-80-mesh stream-sediment samples contain significant copper concentrations. The concentrate samples collected from the streams that drain the rocks of the Wrangellia terrane contain visible scheelite grains, indicating that there may be tungsten-enriched rocks within the terrane.

stream-sediment concentrate samples indicates that massive-sulfide deposits are probably widespread in the metamorphic complex of the Yukon-Tenana terrane, particularly in the rocks north of the Hines Creek fault; however, the size, density, and, therefore, economic significance of such deposits are uncertain. Many of the concentrate samples containing sulfide minerals were collected from watersheds located near known massive-sulfide deposits, even though the rocks of these watersheds lack similar mineral deposits. The belt of sedimentary and volcanic rocks in the southwestern part of the quadrangle in the Upper Chulitna mining district is thought to have potential for economically significant deposits of metallic-minerals in concert with gold and silver production. Cassiterite found in concentrate samples indicates that tin may be abundant enough to be recovered as a byproduct. The granitic rocks in the Ohio Creek area, as well as in other nearby areas, have a potential for tin and tungsten resources. The presence of cassiterite, fluorite, powellite, and scheelite in many of the

concentrate samples indicates that parts of the granitic plutons east of Honolulu may host

tin-molybdenum porphyries and related tungsten-skarn bodies. The area containing flysh,

granitic, and volcanic rocks bounded by the Honolulu thrust fault may host precious- and

base-metal sulfide occurrences, tin porphyry- and greisen-type mineralization, and

This study of stream sediments in the Healy quadrangle identified rocks that would

be favorable to metallic-mineral deposits. The base-metal sulfide-mineral content of the

tungsten-skarn bodies. The gold content of concentrate samples indicates that gold-bearing quartz veins may be widely scattered deposits associated with both plutonic and volcanic Concentrate samples collected in the southeastern part of the quadrangle in the Valdez Creek mining district indicate that there is some potential for the existence of asyet unknown lode- and placer-gold deposits, and base-metal sulfide occurrences associated

with contact zones in the sedimentary and igneous rocks within the study area.

SELECTED REFERENCES Berg, H.C., and Cobb, E.H., 1967, Metalliferous lode deposits of Alaska: U.S. Geological Survey Bulletin 1246, 254 p. Bôttge, R.G., and Northam, M.J., 1985, Availability of land for mineral exploration and development in south-central Alaska: U.S. Bureau of Mines Special Publication,

- 45 p., 21 plates. Capps, S.R., 1919, Mineral resources of the Upper Chulitna region: U.S. Geological Survey Bulletin 692, p. 207-232. Clark, A.L., and Cobb, E.H., 1972, Metallic mineral resources map of the Healy quadrangle, Alaska: U.S. Geological Survey Miscellaneous Field Studies Map MF-394, scale 1:250,000. Cobb, E.H., 1978, Summary of references to mineral occurrences (other than mineral fuels and construction materials) in the Healy quadrangle, Alaska: U.S.
- Geological Survey Open-File Report 78-1062, 112 p. Cox, D.P., Light, T.D., Csejtey, Bela, Jr., and Campbell, D.L., 1989, Mineral resource assessment map of the Healy quadrangle, Alaska: U.S. Geological Survey Miscellaneous Field Studies Map MF-2058-A, scale 1:250,000, 1 sheet. Csejtey, Bela, Jr., Mullen, M.W., Cox, D.P., Gilbert, W.G., Yeend, W.F., Smith, T.E. Warhaftig, Clyde, Craddock, Campbell, Brewer, W.M., Sherwood, K.W., Hickman, R.G., Stricker, G.D., St. Aubin, D.R., and Goerz, D.J., III, 1986, Geology and geochronology of the Healy quadrangle, Alaska: U.S. Geological Survey Open-File Report 86-396, 92 p. Csejtey, Bela, Jr., Mullen, M.W., Cox, D.P., and Stricker, G.D., 1992, Geology and
- Grimes, D.J., and Maranzino, A.P., 1968, Direct-current arc and alternating-current spark emission spectrographic field methods for the semiquantitative analysis of geologic materials: U.S. Geological Survey Circular 591, 61p. Hawley, C.C., and Clark, A.L., 1968, Occurrences of gold and other metals in the Upper Chulitna district, Alaska: U.S. Geological Survey Circular 564, 211p. U.S. Geological Survey Professional Paper 758-B, 47p. Hawley, C.C., Clark, A.L., Hendrick, M.A., and Clark, S.H.B., 1969, Results of geological and geochemical investigations in an area northwest of the Chulitna

geochronology of the Healy quadrangle, south-central Alaska: U.S. Geological

Survey Miscellaneous Investigations Series Map I-1961, scale 1:250,000.

Hickman, R.G., and Craddock, Campbell, 1976, Mineral occurrences near Cantwell, south-central Alaska: Alaska Geological and Geophysical Surveys Special Report Kaufman, M.A., 1964, Geology and mineral deposits of the Denali-Maclaren River area, Alaska: Alaska Division of Mines and Minerals Geologic Report 4, 15 p. King, H.D., Light, T.D., and O'Leary, R.M., 1989, Maps showing distribution and abundance of selected elements in stream-sediment samples from a

River, central Alaska Range: U.S. Geological Survey Circular 617, 19 p.

- reconnaissance geochemical survey of the Healy quadrangle, Alaska: U.S. Geological Survey Miscellaneous Field Studies Map MF-2059-B, scale 1:250,000, 2 sheets. MacKevett, E.M., Jr., and Holloway, C.D., 1977, Map showing metalliferous and selected nonmetalliferous mineral deposits in the eastern part of southern Alaska: U.S. Geological Survey Open-File Report 77-169A, scale 1:1,000,000, 99 p.
- Mining Record, The, 1990, Caprock announces gold reserves on Valdez Creek property: August 1, 1990, v. 101, no 31. Moffit, F.H., 1912, Headwater regions of Gulkana and Susitna Rivers, Alaska, with accounts of the Valdez Creek and Chistochina placer districts: U.S. Geological Survey Bulletin 498, 82 p. Nockleberg, W.J., Lange, I.M., Singer, D.A., Curtin, G.C., Tripp, R.B., Campbell,
- D.L., and Yeend, Warren, 1990, Metalliferous mineral resource assessment of the Mt. Hayes quadrangle, eastern Alaska Range, Alaska: U.S. Geological Survey Miscellaneous Field Studies Map MF-1996-A, 22 p., 4 plates. O'Leary, R.M., Hoffman, J.D., Sutley, S.J., and King, H.D., 1984, Analytical results and sample locality map of stream-sediment and heavy-mineral-concentrate samples from the Healy quadrangle, Alaska: U.S. Geological Survey Open-File Report 84-104, 151 p. Ross, C.P., 1933, The Valdez Creek mining district, Alaska: U.S. Geological Survey

Bulletin 849-H, p. 425-468.

- Saunders, R.H., 1961, Susitna-Maclaren area: State of Alaska Division of Mines and Minerals Report for the year 1961, p. 37-40. Seraphim, R.H., 1975, Denali—A nonmetamorphosed stratiform sulfide deposit: Economic Geology, v. 70, p. 949-959. Sherwood, K.W., Craddock, Campbell, and Smith, T.E., 1976, Mineral occurrences in the upper Wood River, Edgar Creek, and West Fork Glacier areas, central Alaska Range: Alaska Geological and Geophysical Surveys Special Report 14, 13 p.
- Smith, T.E., 1970a, Results of geochemical sampling in the western Clearwater Mountains, Alaska: U.S. Geological Survey Open-File Report 441, 249 p. mining district, Alaska, in Geological Survey research, 1970: U.S. Geological Survey Professional Paper 700-D, p. D146-D152. Division of Geological and Geophysical Surveys Report 60, 72 p. Smith, T.E., Kline, G.L., Kline, J.T., and Coursey, N.D., 1975, Analyses of rock and
- stream-sediment samples, Healy A-2 quadrangle, south-central Alaska: Alaska Division of Geological and Geophysical Surveys Open-File Report AOF-69. Stevens, D.L., 1972, Geology and geochemistry of the Denali prospect, Alaska: American Institute of Mining and Metallurgical Petroleum Engineers Annual Meeting, San Francisco, 1972, Preprint 721-29. Tripp, R.B., Curtin, G.C., Nockleberg, W.J., Huston, D.L., and Hampton, J.R., 1993 Mineralogical maps showing distribution of selected ore-related minerals in the
- nonmagnetic, heavy-mineral-concentrate fraction of stream sediment from the Mount Hayes 1° × 3° quadrangle, east Alaska Range, Alaska: U.S. Geological Survey Miscellaneous Field Studies Map MF-1996-E, scale 1:250,000, 3 sheets. Tuck, Ralph, 1938, The Valdez Creek mining district, Alaska, in 1936: U.S. Geological Survey Bulletin 897-B, p. 109-131. Wahrhaftig, Clyde, 1968, Schists of the central Alaska Range: U.S. Geological Survey Bulletin 1254-E, 22 p.

——— 1970a, Geologic map of the Healy D-2 quadrangle: U.S. Geological Survey

1970b, Geologic map of the Healy D-3 quadrangle: U.S. Geological Survey

Geologic Quadrangle Map GQ-804, scale 1:63,360.

Geologic Quadrangle Map GQ-805, scale 1:63,360. _____ 1970c, Geologic map of the Healy D-4 quadrangle: U.S. Geological Survey Geologic Quadrangle Map GQ-806, scale 1:63,360. ——— 1970d, Geologic map of the Healy D-5 quadrangle: U.S. Geological Survey Geologic Quadrangle Map GQ-807, scale 1:63,360.

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MINERALOGICAL MAPS SHOWING THE DISTRIBUTION OF ORE-RELATED MINERALS IN THE MINUS-30-MESH, NONMAGNETIC HEAVY-MINERAL FRACTION OF STREAM SEDIMENT, HEALY QUADRANGLE, ALASKA